

## On the Ecology and Role of the Wild Flora in the Sustainable Development of the Deltaic Mediterranean Coastal Desert, Egypt

Mahmoud A. Zahran<sup>1</sup>, Yasser A. El-Ameir<sup>2</sup> and Ramadan A. Shawky<sup>3</sup>

1-2 Botany Department, Faculty of Science, Mansoura University, Mansoura, Egypt

3 Plant Ecology and Ranges Department, Desert Research Center, Cairo, Egypt

[ramadan\\_salam@hotmail.com](mailto:ramadan_salam@hotmail.com), [elamier76@yahoo.com](mailto:elamier76@yahoo.com)

### ABSTRACT:

Aiming at the environmental development of the deltaic Mediterranean coastal desert of Egypt, multipurpose projects had been implemented. Studies threw light on the physical environment (climate, geomorphology, hydrogeology, hydrogeochemistry and soil) and natural plant life of the area. Field experiments and laboratory analyses were conducted to test the following: 1-Physical and chemical properties of soil and water, 2- Fiber length measurement of/and production of paper pulps and sheets of paper from fiber halophytes, namely: *Juncus rigidus* and *J. acutus*, 3- Estimation of the nutritive values and palatability of three fodder producing halophytes (*Bassia indica*, *Juncus subulatus* and *Diplachne fusca*), 4- Propagation of *Bassia indica* and *Juncus* spp. under salinity and aridity stress of the area and 5- Soil desalination using *Juncus rigidus* and *J. acutus* and microorganisms. The results obtained are promising and gave the green light to start a wide scale agro-industrial program for the environmental development of the deltaic Mediterranean desert of Egypt.

**Keywords:** Deltaic Med. coastal desert, halophytes, agro-industrial developments

### INTRODUCTION:

Egypt is fairly unique in the distribution of its population, land-use and agriculture, and economic activity which makes it extremely vulnerable to any potential impacts on its water resources and coastal zone. Despite being a large rectangular shaped country with an area of about a million square kilometers, its lifelines are constrained along a narrow T-shaped strip of land (which constitutes less than 5% of its land area) along the Nile and the coast around the Nile Delta [1, 2].

Countries of arid and semi-arid regions face serious problems, namely: high rate population increase, limited natural resources, ill-advised land use and shortage of food, forage and raw material for industries. Therefore, efforts, undoubtedly, would be more successful if they are based on knowledge of the environmental characteristics [3].

Agriculture is quite critical to the national economy as it employs 30% of the work force and contributes 17% to the Gross National Product. Major urban centers, commerce, and industrial activity are also confined to the narrow corridor along the Nile and the coast around its delta. The rest of the country is desert and does not support much population or economic activity [4, 5].

In the Nile Delta region of Egypt, the growing population intensified environmental stress on the agricultural lands and fresh water resources. Such stress call for the optimal utilization of the salt affected-not productive land of the deltaic Mediterranean coastal desert.

The shoreline of Egypt extends for more than 3,500 km along the Mediterranean Sea and the Red Sea. The Nile delta coast stretches about 300 km and hosts a number of highly populated cities such as Alexandria, Port-Said, Rosetta, and Damietta. These cities are also critical centers of industrial and economic activity. In addition, the Nile delta coastal zone includes a large portion of the most fertile low land of Egypt. The coastal zone suffers from a number of major problems including population pressure, interference of land use, pollution, water logging and lack of institutional capabilities for integrated management [1, 6].

The present paper describes briefly results obtained from researches carried out on two scientific projects funded by IFS of Sweden and FRCU of the Supreme Council of Egyptian Universities. The main parts of the paper are: the physical environment of the study area (location, climate, geomorphology, hydrogeology, hydrogrochemistry and soil), plant life, plants of agro-

industrial potentialities, soil biological desalinations, conclusions and references.

## THE PHYSICAL ENVIRONMENT

### 1. Location and climate

The Mediterranean coastal desert in Egypt is classified into 3 sections: The western section extends between Sallum on the Libyan border, eastwards to Abu Qir for about 570 km whereas the eastern section extends for 240 km between Port Said and Rafah on the Palestinian border. The middle deltaic section extends for about 180 km from Abu Qir eastwards to Port Said with an average width in a N-S direction for about 15 km from the sea "Fig.1" [7].

The climate of this coastal belt is arid: hot and dry. The main maximum and minimum temperature vary between 17.9-31.31 °C and 8.2-21.5 °C in summer and winter, respectively. Relative humidity varies between 69-84 % and evaporation rate ranges between 2.8-5.4 mm/day Piche. More than 80% of rain occurs during Nov-Feb. period, summer is dry. Total annual rainfall varies between 102.3-160.0 mm. Winds are generally light but violent dust storms and sand pillars aren't rare. El-Khamasin winds blow occasionally for about 50 days during spring-summer. N, NW and SW winds together with El-Khamasin are responsible for the formation of sand dunes and other land forms of the area [3, 7].

### 2. Geomorphology

The Deltaic Mediterranean coastal desert may be classified into 4 geomorphic units: the extensive backshore flats, the flooded low lands, the peripheral lakes and the coastal dunes [8].

#### 2.1. The extensive backshore flats

These flat lands occupy most of the study coastal desert, not more than 2 m a.s.l, sometimes covered by flat expanses of beach sand. The western part: Rosetta, Sidi Yousef and Burullus plains are flooded during winter storm surges. Salinity problem is quite obvious at several places where mineral salts are concentrated at the soil surface through evaporation.

#### 2.2. The flooded low lands

The dominant factors that affect the formation of the flooded basin are the occasional rising of saline water

level in the lakes and/or the evaporation of surface water and subsoil water by capillary actions. Many areas south the shoreline are inundated by water more or less permanently giving way inland to areas obviously flooded each year. Sabkhas, salinas and marshes are developed in the vicinity of the permanently wet areas in various stages of desiccation.

#### 2.3. The peripheral lakes

The deltaic morphology is characterized by 3 shallow lakes occupying wide areas of the northern part of delta, these are: Lake Manzala (east), Lake Burullus (middle) and Lake Idku (west). These lakes receive the main bulk; of the drainage water collected from the Nile Delta. They are separated from the sea by strips of land that are very narrow in several places and are connected with the sea through outlets. Many areas around these lakes are more or less permanently covered by water as a result of flooding from the lakes and inland canals. Some areas develop salt flats while others develop marshes.

#### 2.4. The coastal sand dunes

The dominant N and NW winds transported very large amounts of sand to the beaches and further landward. These backshore plains are the main feeders of these coastal dunes, most of which are low and narrow with width ranges from 0.5 to 1.5 km. Some dunes with small depressions in between make temporary lakes (like in Baltim).

These dunes represent a collecting area for the rainfall water and obstacle for the run-off water. Fresh water seepage from these dunes is used for irrigation purposes. However, the vertical infiltration of water has replenished the underneath subsoil aquifer, especially in winter. So it is easy to obtain fresh water from the hollows beside and between the dunes which explains the flourishing of palms, and some other cultivations near Kafr El-Bateikh, Zaian and Baltim areas.

These dunes may be classified into backshore dunes (up to 25 m high) and foreshore dunes which separate the north margin of the lakes and depressions from the sea.

### 3. Hydrogeology

This study is an approach towards the adequate understanding of the hydrological and hydrochemical relationships that may affect the circulation of water and salts in the shallow ground water as well as in the surface water to serve land reclamation of the deltaic Mediterranean coast of Egypt.

#### 3.1. Surface water

The surface water system comprises the River Nile branches, the irrigation-drainage network and the open ditches that covers the northern newly reclaimed lands. The irrigation network generally starts from the south and extends radial northwards, while the alternating drainage network debouch their water in the natural lakes and the Mediterranean Sea. Generally, the irrigation channels follow high topographic stretches, while the drainage canals follow low land.

#### 3.2. Subsoil water

The subsoil section is formed mainly of sand, silt and clay lenses, inter fingered with different ratios. Emphasis has been given to study the soil section till the first appearance of the subsoil water table. The depth of water in the 18 boreholes dug in the area ranges between 80 cm and 20 cm arranged in non-vegetated areas.

The subsoil water is very close to ground surface (less than 1 m depth at many locations) and is occasionally intermingled with the surface water from drains, canals and/or lakes. Although the depth to subsoil water varies from 80 cm to more than 2 m, yet, several anomalies noted were attributed to local conditions. The closeness of the subsoil water to the ground surface is harmful to the crop yield in the cultivated areas and may deteriorate the soil.

The variation in depth of water of the subsoil zone is possibly attributed to the surface relief, the miss-use of irrigation water and the inadequate drainage system or the soil texture. Moreover, the potentiometric surface of the groundwater in this zone is governed by the hydrostatic pressure, due to the presence or absence of the impervious clays at the

bottom of the subsoil section. Certainly, the relation of the subsoil water with the deep groundwater is very important for future study. Such type of study needs not only shallow to moderate drilling, but also deep boring to penetrate the different subsurface zones in several localities.

#### 3.3. Groundwater

The subsurface geological setting and/or the lithology of the different water-bearing formations generally control the occurrence and movement of groundwater. The Quaternary succession in the northern Nile Delta area could be subdivided into two water-bearing units depending upon the stratigraphic succession. These two units however seem separated from each other by a clay layer near the bottom of Bilqas Fm (Holocene), but they are hydraulically connected. The upper unit is considered as semi-pervious layer while the lower one is considered as the main aquifer of the Nile Delta. It consists of thick sand and gravel sequence of Mit Ghamr Fm (Pleistocene). Study of the lateral and vertical variations of this clay layer throughout the coastal area is very important because of its effect on the subsoil water and ground water regime.

The lower unit (main aquifer) attains an average thickness of more than 700 m, dominated by permeable sands and gravels with minor clay lenses. This aquifer is underlain by a thick marine sequence mainly Neogene clay. The main aquifer is considered almost a confined aquifer where the hard sticky clay cap of Bilqas Fm covers it. Meanwhile, it is underlain by the Neogene marine clay. However, the hydrogeological setting of this aquifer differ from place to place depending on the presence or absence and condition of this cap layer.

The Delta aquifers, in general, are mainly recharged through the influent sectors of the two Nile branches especially in front of the barrages, also through infiltration from the irrigation-drainage network covering approximately the entire delta. Deep percolation from the flood irrigated fields and the occasional winter rainfall has a major role in recharging the aquifers. However, groundwater discharges into the effluent sectors of the Nile Branches at the downstream parts of corresponding

low levels. It also discharges indirectly into the Mediterranean Sea and the northern lakes.

The groundwater level in the Quaternally aquifer fluctuates all over the year in response to the recharge-discharge processes. From field measurements and the groundwater contour maps prepared for both the subsoil zone and the main aquifer, it has been found that [8]:

a) The main groundwater still, flows towards the north.

b) Wells of different depths and at the same locality show various piezometric heads usually increasing with depth e.g. El-Wastani and El-Hamoul water wells (T.D. 115 m). This phenomenon may be attributed to the vertical variations in lithology and to the clay thickness interfingering the aquifer sediments, where it may affect the piezometric pressure.

c) The ground water head in most localities is very close to the ground surface and sometimes water flows or seeps above the ground surface as shown at El Wastani and El Hamoul wells.

d) Upward flow takes place, where the piezometric head of the lower aquifer is higher than the water table of the subsoil section.

### **3.4. Chemical properties of water**

Thirty samples of water have been collected covering the deltaic coast between Rosetta and Damietta. These samples represent surface water (6 samples), subsoil water (18 samples), and groundwater (6 samples). The surface water includes samples collected from Bahr Tira Canal and 5 main drains in the area. The subsoil water samples were collected within 2m deep boreholes, dug by a manual auger-hole. The samples collected from 5 wells drilled for the purpose of the present study and from an already existing flowing well at El Wastani area "Fig. 2" [8].

The results obtained show that the water, in general, is salty to brine. It has a wide range of salinity that may be summarized in the following:

1- Dealing with surface water; the salinity of the drains water ranges from 1.6 gm/L to more than 30 gm/L, meanwhile the canal water is relatively deteriorated at the northern part of the study area. A

sample collected from Bahr Tira Canal north El Khashaa showed a salinity of 1.24 gm/L. This means that there is a partial mixing from the groundwater seepage and/or drain water to the canals at their northern extremities.

2- The subsoil water has salinity ranging from 3.6 gm/L to more than 250 gm/L. The low salinity value is restricted in the vicinity of the sand dunes.

3- The groundwater has salinity ranging from 4.3 gm/L to about 90 gm/L in the coastal strip of the study area. The low salinity value has been recorded at El Wastani and Sidi Youssef wells.

### **3.5. Soil characteristics**

The soil of the deltaic Mediterranean coastal desert is mainly sandy on marine deposits. They are, in general, salt affected with various degrees of salinity. EC value varies widely between 1.66 mmohs/cm and 80.04 mmohs/cm with pH between 7.0-7.8. The organic carbon and calcium carbonate contents are, generally, low with values between 0.15%-1.3% and 0.7%-18.1%, respectively. As regard soil classifications the soil of this coastal desert belongs to the solon chalk type according to the FAO and to the Entisol type according to the American systems.

### **4. Plant Life**

The plant life of the deltaic Mediterranean coastal desert had been studied in 4 representative sea-landward belt transects in 4 sites located in: Kafr EL-Bateikh, Kalabshu, Baltim and Rosetta. The length of each transect (N-S direction) was 10 km with a width (E-W direction) of 5 km "Figs 1, 2". The results of the vegetation analysis of these transects show that the study coastal desert may be categorized ecologically into 8 habitats, namely: bare-sandy beach, sand mounds, barren salt marshes, sand flats, sand dunes, vegetated salt marshes, reed swamps and fertile non-cultivated lands.

#### **4.1. Bare sandy beach zone**

This zone extends for about 200 m southward along the coast in the four study sites. This zone is subject to the rise and fall of tide that produces anaerobic soils which support no vegetation. The changes in tidal inundation time with elevation above mean sea-level and evaporation from the surface result in salt

accumulation. Tidal movements and sea currents constantly disturb any possibility for vascular plant establishment.

#### 4.2. Sand mounds

This habitat type usually occupies the shore-line zone extending for about 250 m width. It is present in three sites. Kafr El-Bateikh, Qalabshu and Rosetta but it is absent in Baltim. This habitat can be subdivided into two types:

##### 4.2.1. Low sand mounds

These mounds are dominated by *Zygophyllum aegyptium* in the three study sites.

##### 4.2.2. Raised sand mounds

These mounds are co-dominated by *Holocnemum strobilaceum* and *Arthrocnemum macrostachyum* in Kafr El-Bateikh site, dominated by *Arthrocnemum macrostachyum* in Qalabshu site and dominated by *Elymus farctus* in Rosetta site. Few individuals of annual species have been recorded in the sand mounds such as *Cakile maritima*, *Senecio glaucus* and *Salsola kali*.

#### 4.3. Barren salt marshes

The barren salt marshes cover a width of about 1-2.5 km. This habitat supports a relatively low plant diversity and constitutes a slippery black-salt marshes, that are dry most of the year. This zone is not represented in Baltim site but it is well represented in the other three study sites.

In some areas, this semi-barren landscape contains a distinct microhabitat in a form of scattered small hummocks that are elevated above the barren surface. These microhabitats support the growth of *Halocnemum strobilaceum*, *Arthrocnemum macrostachyum* and *Zygophyllum aegyptium*. Due to strong winds and water washing of the surface, some of these habitats are subject to erosion causing plant growth to be restricted in relic areas.

#### 4.4. Sand flats

These areas are more or less flat (sand sheet) with slight undulations. They are found in the four study sites.

In Kafr El-Bateikh site, the sand flat extends for about 500 m length and are located at about 2 km from the seashore. It lies between the salt marshes and reed swamps in the area. This habitat type is dominated by *Suaeda vera* associated with *Stipagrostis lanata*, *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum* and *Zygophyllum aegyptium*. In Qalabshu site, the sand flats can be divided into two types:

**a- Extensive sand flats** of about 600 m width south of the barren salt marsh zone. In this sub habitat, two communities are distinguished: *Elymus farctus* community in the northern part and *Zygophyllum aegyptium* community in the southern part of this site.

**b- Irregular sand flats** represented by undulated belt of about 500 m width south of the extensive sand flat belt. These flats dominated by: *Arthrocnemum macrostachyum* and *Zygophyllum aegyptium*.

The sand flats in Baltim site form a narrow belt of about 200 m width next to the bare sandy beach zone dominated by *Silene succulenta*. In Rosetta site, the sand flats are slightly raised with width of about 800 m occupying a belt next to the barren salt marsh zone. This habitat is dominated by *Sporobolus virginicus*.

In the sand flats, the common associated perennial species are: *Alhagi graecorum*, *Cynodon dactylon*, *Calligonum comosum* and *Launaea resedifolia* while, the associated annual species are: *Cakile maritima*, *Senecio glaucus* and *Salsola kali*.

#### 4.5. Sand dunes

Four kinds of sand dunes are recognized in the study area: mobile dunes partially stabilized dunes, old stabilized dunes and cultivated dunes.

**a- Mobile dunes** are usually of varying sizes and are generally characterized by the growth of *Elymus farctus*, *Calligonum comosum* (at Qalabshu), *Silene succulenta*, *Cyperus capitatus* (at Baltim) and *Lotus creticus* (at Rosetta).

**b- Partially stabilized dunes** are denser than mobile dunes in vegetation. These dunes are dominated by *Stipagrostis lanata*, *Asparagus stipularis* (at Qalabshu) and *Echinops spinosissimus* (at Rosetta).

**c- Old stabilized dunes** are vegetationally the richest dunes because they become protected from



the direct effects of maritime influences. These dunes are dominated by *Echinops spinosissimus*, *Moltkiopsis ciliata* and *Panocratium maritimum* at Qalabshu and Baltim sites.

**d-Cultivated dunes** at Qalabshu, Baltim and Rosetta are characterized by shrubs of figs, grapes and palm trees together with some vegetable cultivations such as Tomatos and Water Melons. The common species in these dunes are: *Alhagi graecorum*, *Thymelaea hirsuta*, *Stipagrostis scoparia*, *Launaea resedifolia* *Lycium schweinfurthii*, (perennials), *Senecio glaucus*, *Cakile maritima*, *Plantago squarrosa*, *Lotus halophilus*, *Rumex pictus*, *Ononis serrata* and *Cutandia memphitica* (annuals).

#### 4.6. Vegetated Salt marshes

The salt marsh habitats are characterized by high level of salinity. They may occupy the depressed areas between the sand dunes. They are usually wetted by sea water due to fluctuations of water table level. Two types of salt marshes are distinguished in the study area:

**a- Dry salt marshes** which occupy the saline habitats with relatively deep water table. These are dominated by *Arthrocneum marcrostachyum*, *Limonium angustifolium*, and *Halocneum strobilaceum*. The common associated species are: *Zygophyllum aegyptium*, *Inula crithmoides*, *Sporobolus virginicus*, *Sporobolus spicatus*, *Frankenia hirsuta*, *Limonium pruinum* and *Cressa cretica*.

**b- Wet salt marshes** are the saline habitats with relatively shallow water table and are usually wet. This habitat is frequent in Qalabshu and Baltim sites and it is dominated by *Juncus rigidus* and *Juncus acutus*. The common associated species are: *Bolboschoenus maritimus*, *Cyperus laevigatus*, *Juncus subulatus*, *Halimione portulacoides*, *Phragmites australis* and *Tamarix tetragyna*.

#### 4.7. Reed Swamps

The swampy habitats are frequent in the study area. They occupy most of the landward area of the transects at the border of the fertile non-cultivated and agricultural lands. They are formed by the accumulation of water seeped from northern lakes, Mediterranean Sea and/or drainage system of the delta in depressed areas. The soil of this zone is

covered with water all the year round and is dominated by reed swamp vegetation. In areas with high salinity level, *Phragmites australis* is the dominant while in less saline areas, *Typha domingensis* predominates. The associate species include water- loving species such as: *Cyperus articulatus*, *Cyperus laevigatus*, *Schoenoplectus litoralis*, *Bolboschoenus maritimus*, *Persicaria salicifolium*, *Pluchea dioscoridis* and *Paspalidium geminatum*. Some halophytic species grow on the saline fringes of the swamps such as: *Juncus rigidus*, *J. acutus*, *J. subulatus*, *Inula crithmoides*, *Tamarix tetragyna*, *Carex extensa* and *Halimione portulacoides*.

#### 4.8. Fertile non-cultivated lands

This habitat had been previously reclaimed for cultivation, but due to the declined land quality by continuous neglection caused increased salinity and shallow water table, the land is degraded and desertified. This habitat type is mainly cultivated with vegetables such as water melon and tomato as well as fruit trees (orchards) such as date palm, guagava and citrus. Specific plant life has been evolved including growth of weed flora and invasion of many plant species from the neighboring cultivated lands. Generally, the fertile non-cultivated lands occur between the agricultural land and the coastal area.

This habitat is dominated by *Cynodon dactylon*, *Pluchea dioscoridis* and *Convolvulus arvensis*. The common associated species are: *Lotus corniculatus*, *Cynanchum acutum*, *Phyla nodiflora*, *Polypogon viridis*, *Amaranthus graceizans*, *A. ascendens* and *Symphyotrichum squamatus*.

#### PLANTS OF AGRO-INDUSTRIAL POTENTIALITIES

Floristic elements of the natural vegetation types of the deltaic Mediterranean coast may be categorized, according to their economic use, under 4 main groups, namely: 1- drug plants, 2- livestock fodder plants, 3- fiber plants and 4- wood plants.

Five halophytic species: *Juncus rigidus*, *J. acutus*, *J. subulatus*, *Diplachne fusca* and *Bassia indica*, were chemically analyzed, the first two species are fiber producing plants whereas the others are fodder plants. The industrial potentialities of these plants

were tested. Propagation of *Juncus rigidus*, *J. acutus* and *Bassia indica* in salt affected areas of the deltaic Mediterranean coast was experimented.

### 1. Fiber plants

*J. rigidus* and *J. acutus* are highly salt tolerant rushes widely occur in the inland and coastal salt marshes of Egypt. Both are cumulative halophytes [9].

*J. rigidus* and *J. acutus* have many important uses both in old and recent times. They were used in earlier days in making mats, sandals and writing pens [10]. Recently, it was found by the Authors of reference [11], that the seeds of these rushes are rich in fatty acids. Reference [12] found 13 amino acids in these seeds. However, the most important industrial use of *J. rigidus* and *J. acutus* is as culms (the green leafy - shoots) which are used as raw material in paper industry.

The fiber length measurement indicate that the mean values of *J. rigidus* and *J. acutus* culms range between 849.1 - 1451.7 and 791.0 - 1592.6 micro, respectively. The chemical analyses and pilot plant experiments proved that the culms of *Juncus* contain low ash (6.5%), low lignin (13.3%), high  $\alpha$ - cellulose (39.8%) and high yield of unbleached pulp (36.8%). The strength properties of the depithed *Juncus* pulp are much higher than those of rice straw and bagasse. The grade index of *Juncus* pulp = 73% as compared to that of the imported softwood long fiber pulp (100%) and to those of rice straw (24%) and bagasse (42%), [13].

Field establishment experiment was conducted in the poorly drained salt affected land associated with Lake Manzala. The results of this experiment [14] show that both *Juncus* spp. may be cultivated on such bad non-productive soil. After one year of growth it was found that the mean heights of *J. rigidus* and *J. acutus* culms were 162 cm and 85 cm, mean fresh weight were 4.96 kg/plot<sup>-1</sup> and 2.81 kg/plot<sup>-1</sup> and the mean dry weights were 1.95g/plot<sup>-1</sup> and 1.11 kg/plot<sup>-1</sup>, respectively [15].

### 2. Livestock Fodder Plants.

The chemical analyses of three halophytes namely *Bassia indica*, *Juncus subulatus* and *Diplachne fusca* proved their high nutritive values. According to International Journal of Life Sciences and Technology (2017), Volume 10, Issue 2, Page(s):14-32

reference [16], the green branches and hay of *B. indica* contain ; 84.2% and 7.7% water, 3.4% and 17.6% crude protein, 5.2% and 35.9% N. Free extract, 0.4% and 1.6% fats, 4.1% and 23.9% fiber and 2.7% and 14.31% ash. For *J. subulatus* and *D. fusca*, the moisture content, the crude protein, the crude fiber and ash content, on dry weight basis were; 7.01% & 5.10%, 14.96% & 8.18%, 22.85% & 26.8% and 9.62% & 10.97%, respectively. For the commercial fodder and the alfalfa hay, the crude protein and crude fiber contents are: 16.6% & 13.95 and 16.0% & 40%, respectively. Rams feeded on *Bassia* materials gained weight without side effects. On the other hand, rabbits feeded on materials of *Juncus* and *Diplachne* lost weight. Rabbits seem not accept these two fodders alone but it is, thus, preferable to use them instead of clover in the commercial fodder (up to 40%).

Propagation experiment on *B. indica* was conducted in a saline land in Om El-Reda village, located at about 4 km south of the Mediterranean Sea and about 20 km west of Damietta city. The conventional crops, usually cultivated in the other productive lands of the Nile Delta, would fail to grow in this land due to its high salinity. Propagation of *B. indica* was by seeds collected from its natural stands in the Nile Delta. Experiment continued for 7 months starting from January 1988. Shoot harvesting was carried out 3 times: 3.5 and 7 months after cultivation. The results are encouraging. The vegetative yield of *B. indica* fodder halophytes increased by aging being: 0.5 ton/Feddan, 2.2 tons/Feddan and 4.5 ton/Feddan on dry weight basis, respectively.

Grazing potentiality of *B. indica* was observed in the site of the experiment. Ruminant (cattle and sheep) and non-ruminant (donkeys) animals left to graze freely for about one month. All animals ate the plant without any symptoms of toxicity [17].

### BIOLOGICAL SOIL DESALINATION

Many attentions had been paid to the reclamation of the saline soils particularly in arid land countries. However, addition of soil amendments and fertilizers and the retention of salts further complicate the problem. Soil biological desalination seems to be the more safe way. In the present study, improvement of

the salt affected lands of the deltaic Mediterranean coast had been tested using *Juncus* (fiber) plants and microorganisms.

The success of *Juncus* cultivation in the saline soil was associated with another advantage that increases its economic values. Being cumulative halophytes, *J. rigidus* and *J. acutus* accumulate excess salts, they absorb from soil in the upper parts of their culms [13]. "Each harvest is diminishing the salt content of the soil and/or ground water" [18].

Zahran *et al.*, [13] found that the growth, and consequently the vegetative yields of *J. subulatus* fodder halophyte was higher in the saline soil inoculated with AV mycorrhizal fungus (*Glomus mosseae*) when compared to the plants grown in the non-inoculated saline soil. It seems that this fungus succeeded to overcome the detrimental growth effect of soil salinity and, thus improved soil productivity. Other microorganisms, namely: algae, bacteria and actinomycetes, have been also successfully tested [19, 20].

## CONCLUSION

The results obtained reveal that the deltaic Mediterranean coastal desert can be developed agro-industrially using its local renewable natural resources, namely: soil, water and plants. The non productive salt affected land can be changed to productive one through the propagation of certain halophytes of agro-industrial potentialities. The vegetative yields of the introduced non-conventional crops will secure the raw materials of various industries e.g fodder, drug and paper. However, for the environmental independence of this coastal desert, more studies are needed. These include:

- 1- Production of clean energy from sun and wind.
- 2- Fish and shrimp production from permanently flooded swampy habitat (reed swamps and mangrove swamps).
- 3- Establishment of houses using the local raw materials.
- 4- Honey bee production.

Implementation of the above mentioned study will certainly change this non-productive coastal desert

with very few population to productive area that attract more people to inhabit it.

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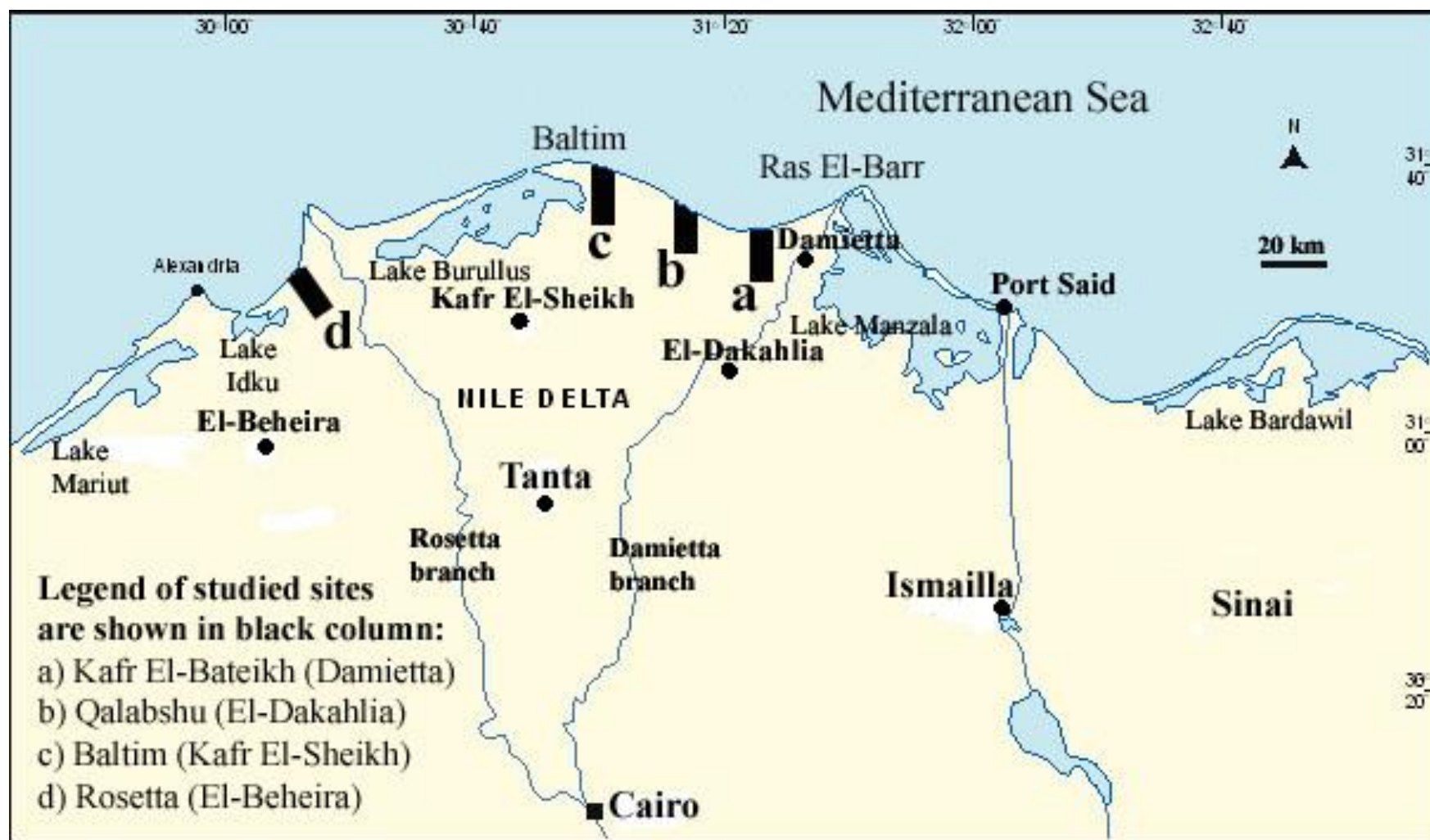


Fig. 1. Map of the Nile Delta of Egypt showing the deltaic Mediterranean coastal desert and the four studied.



Fig. 2. Location map of water samples (●).

a- Kafr El-Bateikh (Damietta)			b- Qalabshu (El-Dakahlia)			c- Baltim (Kafr El-Sheikh)			d- Rosetta (El-Beheira)		
Mediterranean Sea			Mediterranean Sea			Mediterranean Sea			Mediterranean Sea		
	1			1			1			1	
Za	2		Za	2		Ss	2		Za	2	
Am	3	Hs	Am	3		Ss	3	Cyc	Ef	3	
	4			4		Ja	4	Jr		4	
Hs	5	Am	Ef	5	Za	Hs		Am	Spv	5	
Sv	6		Am	6	Za	Pm	5	Es	Lc	6	
Pd	7		Ef	7	Cc	Cd	6		Am	7	La
Pd	8		Sl	8	As	Ft	7		Es	8	
Ft	9		Am	9	Hs	Td	8		Ca	9	
			Ja		Jr	Cultivated lands			Td	10	
			Es	10	Mc						
Cultivated lands			Cultivated lands						Cultivated lands		

Fig. 3. Sketch diagram of the zonation pattern of the habitat types of 4 sea, landward belt transects each 5 km width and 10 km length representing the plant life the four study sites of the Deltaic Mediterranean coastal belt of Egypt.



a- Legend numbers of the habitat types of the Deltaic Mediterranean coastal desert:

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1- Bare sandy beach	1- Bare sandy beach	1- Bare sandy beach	1- Bare sandy beach
2- Low Sand mounds	2- Low Sand mounds	2- Sand flats	2- Low Sand mounds
3- Raised sand mounds	3- Raised sand mounds	3- Mobile sand dunes	3- Medium sand mounds
4- Barren salt marshes	4- Barren salt marshes	4- Salt marshes	4- Barren salt marshes
5- Salt marshes	5- Extensive sand flats	5- Stabilized sand dunes	5- Sand flats
6- Sand flats	6- Irregular sand flats	6- Fertile non-cultivated lands	6- Mobile sand dunes
7- Reed swamps	7- Mobile sand dunes	7- Orchards	7- Salt marshes
8- Fertile non-cultivated lands	8- Partial stabilized dunes	8- Reed swamps	8- Partial stabilized dunes
9- Orchards	9- Salt marshes		9- Fertile non-cultivated lands
	10- Stabilized sand dunes		10- Reed swamps

b- Legend of the community types of the Deltaic Mediterranean coastal desert, Egypt.

- |  |                                       |
|--|---------------------------------------|
| 1- Am: <i>Arthrocnemum macrostachyum</i> | 13- La: <i>Limonium angustifolium</i> |
| 2- As: <i>Asparagus stipularis</i>       | 14- Lc: <i>Lotus creticus</i>         |
| 3- Ca: <i>Convolvulus arvensis</i>       | 15- Mc: <i>Moltkiopsis ciliata</i>    |
| 4- Cc: <i>Calligonum comosum</i>         | 16- Pa: <i>Phragmites australis</i>   |
| 5- Cd: <i>Cynodon dactylon</i>           | 17- Pd: <i>Pluchea dioscoridis</i>    |
| 6- Cyc: <i>Cyperus capitatus</i>         | 18- Pm: <i>Pancratium maritimum</i>   |
| 7- Ef: <i>Elymus farctus</i>             | 19- Sl: <i>Stipagrostis lanata</i>    |
| 8- Es: <i>Echinops spinosissimus</i>     | 20- Ss: <i>Silene succulenta</i>      |
| 9- Ft: Fruit trees                       | 21- Sv: <i>Suaeda vera</i>            |
| 10- Hs: <i>Halocnemum strobilaceum</i>   | 22- Spv: <i>Sporobolus virginicus</i> |
| 11- Ja: <i>Juncus acutus</i>             | 23- Td: <i>Typhadomingensis</i>       |
| 12- Jr: <i>Juncus rigidus</i>            | 24- Za: <i>Zygophyllum aegyptium</i>  |

**Appendix 1.** Enumerated list of some plants in Deltaic Mediterranean coastal of Egypt, together with their duration, growth forms, chorotypes, and habitats in the different phytogeographic regions of Egypt. Life forms: Th = Therophytes; G = Geophytes, H = Hemicryptophytes; Ch = Chamaephytes; He = Helophytes; Nph = Nanophanerophytes; MMPh = Meso&Megaphanerophytes; P = Parasitic; Chorotypes: ME = Mediterranean, SA-SI = Saharo-Sindian, S-Z = Sudano-Zambezian, ER-SR = Euro-Siberian, IT-TR = Irano-Turanian, Cult. = Cultivated, COSM = Cosmopolitan, AUST= Australian, PAL = Palaeotropical, NEO = Neotropical, PAN = Pantropical.

No.	Taxa	Life-span	Life-form	Floristic category	Deltaic Mediterranean coastal					
					Sand formations			Salt marshes	Reed swamps	Fertile non-cultivated land
					Sand mounds	Sand flats	Sand dunes			
1	<i>Acacia nilotica</i> (L.) Delile	Per	Nph	AUST		+				
2	<i>Aegilops bicornis</i> (Forssk.) Jaub	Ann.	Th	ME+SA-SI	+	+				+
3	<i>Aetheorhiza bulbosa</i> (L.) Cass.	Per.	G	ME		+		+		
4	<i>Alhagi graecorum</i> Boiss	Per.	H	PAL		+				+
5	<i>Amaranthus lividus</i> L.	Ann.	Th	ME+IR-TR		+				+
6	<i>Ammannia baccifera</i> L.	Ann.	Th	S-Z+IR-TR		+				+
7	<i>Anagallis arvensis</i> var. <i>arvensis</i> L.	Ann.	Th	COSM						+
8	<i>Anagallis arvensis</i> var. <i>caerulea</i> (L.) Gouan	Ann.	Th	COSM						+
9	<i>Anchusa hamilis</i> (Desf.) I.M. Johnst.	Ann.	Th	ME+SA-SI		+				+
10	<i>Arthrocnemum macrostachyum</i> (Moric.) Moris et De/Ponte	Per.	Ch	ME+SA-SI		+		+		
11	<i>Arundo donax</i> L.	Per.	He,G	CULT+NAT						+
12	<i>Asparagus stipularis</i> Forssk.	Per.	G	ME+SA-SI		+				+
13	<i>Astragalus hamosus</i> L.	Ann.	Th	ME+IR-TR		+				+
14	<i>Atractylis carduus</i> (Forssk.) C.Chr.	Per.	H	SA-SI+ME	+	+				
15	<i>Atriplex halimus</i> L.	Per.	Nph	ME+SA-SI		+		+		
16	<i>Atriplex portulacoides</i> L.	Per.	Ch	ER-SR+ME+IR-TR				+		

17	<i>Atriplex prostrata</i> DC.	Ann.	Th	ME+ER-SR+IR-TR		+		+		
18	<i>Atriplex semibaccata</i> R.Br.	Per.	H	AUST		+		+		
19	<i>Avena fatua</i> L.	Ann.	Th	PAL	+	+				+
20	<i>Bassia indica</i> (Wight) A.J.Scott.	Ann.	Th	S-Z+IR-TR		+				+
21	<i>Bolboschoenus glaucus</i> (Lam.) S.G.Smith	Per.	G	COSM				+		
22	<i>Brassica nigra</i> (L.) Koch	Ann.	Th	COSM		+				+
23	<i>Brassica tournefortii</i> Gouan	Ann.	Th	ME+IR-TR+SA-SI		+				+
24	<i>Bromus diandrus</i> Roth	Ann.	Th	ME	+	+				+
25	<i>Cakile maritima</i> Scop. subsp. <i>aegyptiaca</i> (Willd.) Nyman	Ann.	Th	ME+ER-SR	+	+				+
26	<i>Calligonum polygonoides</i> L. subsp. <i>Comosum</i>	Per.	Nph	SA-SI+IR-TR	+	+				+
27	<i>Carduus getulus</i> Pomel	Ann.	Th	SA-SI		+				+
28	<i>Carex extensa</i> Good.	Per.	G	ME+ER-SR				+		
29	<i>Carthamus lanatus</i> L.	Bi	Th	ME						+
30	<i>Carthamus tenuis</i> (Boiss & Blanche) Bornm	Ann.	Th	ME		+				+
31	<i>Centaurea calcitrapa</i> L.	Bi	Ch	ME+ER-SR		+				+
32	<i>Centaurium pulchellum</i> (Swartz) Durce.	Ann.	Th	ME+IR-TR+ER-SR		+		+		
33	<i>Chenopodium album</i> L.	Ann.	Th	COSM		+				+
34	<i>Chenopodium murale</i> L.	Ann.	Th	COSM		+				+
35	<i>Chrozophora plicata</i> (Vahl) A. Juss.	Ann.	Th	S-Z+SA-SI		+				+
36	<i>Cistanche phelypaea</i> (L.) Cout.	Per.	P,G	SA-SI+ME		+				+
37	<i>Convolvulus arvensis</i> L.	Per.	H	COSM	+	+				+
38	<i>Conyza bonariensis</i> (L.) Cronquist, Bull.	Ann.	Th	NEO		+				+
39	<i>Corchorus olitorius</i> L.	Ann.	Th	PAN		+				
40	<i>Cressacretica</i> L.	Per	H	ME+PAL	+	+				+
41	<i>Cutandia memphitica</i> (Spreng.) Benth.	Ann	Th	ME+IR-TR+SA-SI		+				
42	<i>Cynanchum acutum</i> L.	Per.	H	ME+IR-TR	+	+				+
43	<i>Cynodon dactylon</i> (L.) Pers.	Per.	G	PAN	+	+				+
44	<i>Cyperus capitatus</i> Vand.	Per.	G	ME	+	+				



45	<i>Cyperus conglomeratus</i> Rottb.	Per.	G	SA-SI+S-Z	+	+				
46	<i>Cyperus laevigatus</i> L.	Per.	G,He	PAN					+	
47	<i>Daucus litoralis</i> Sm.	Ann.	Th	ME	+	+				+
48	<i>Echinop spinosus</i> L.	Per.	H	ME+SA-SI		+				+
49	<i>Echium angustifolium</i> Mill. subsp. <i>sericeum</i>	Per.	H	ME		+				+
50	<i>Elymus farctus</i> (Viv.) Runem. SSP <i>Juncoum</i> Runem.	Per.	G	ME	+		+			
51	<i>Emex spinosa</i> (L.) campd	Ann.	Th	ME+SA-SI		+				+
52	<i>Erodium laciniatum</i> (Cav.) Willd.	Ann.	Th	ME	+	+				+
53	<i>Euphorbia helioscopia</i> L.	Ann.	Th	ME+IR-TR+SA-SI						+
54	<i>Euphorbia peplus</i> L.	Ann.	Th	ER-SR+ME+IR-TR						+
55	<i>Ficus carica</i> L.	Per.	Nph	CULT.		+				
56	<i>Frankenia pulverulenta</i> L.	Ann.	Th	ME+ER-SR+IR-TR		+		+		
57	<i>Halocnemum strobilaceum</i> (Pallas) M. Bieb.	Per.	Ch	ME+IR-TR+SA-SR		+		+		
58	<i>Heliotropium curassavicum</i> L.	Per.	Ch	NEO		+				+
59	<i>Hordeum murinum</i> L.	Ann.	Th	ME+IR-TR+ER-SR	+	+				+
60	<i>Ifloga spicata</i> (Forssk.) Sch. Bip.	Ann.	Th	SA-SI+ME	+	+				+
61	<i>Imperata cylindrica</i> (L.) Raeusch.	Per.	H	PAL+ME		+				+
62	<i>Juncus acatus</i> L.	Per.	He	ME+IR-TR+ER-SR					+	
63	<i>Juncus rigidus</i> Desf.	Per.	He,G	ME+SA-SI+IR-TR					+	
64	<i>Juncus subulatus</i> Forssk.	Per.	He,G	ME+IR-TR+SA-SR					+	
65	<i>Lactuca serriola</i> L.	Ann.	Th	ME+IR-TR+ER-SR		+				+
66	<i>Launaea fragilis</i> (Asso) Pau	Per.	H	ME+SA-SI	+	+				+
67	<i>Limbarda crithmoides</i> (L.) Dumort.	Per.	Ch	ME+ER-SR+SA-SI				+		
68	<i>Limonium narbonense</i> Mill.	Per.	H	ME		+		+		
69	<i>Limonium pruinosum</i> (L.) Chaz.	Per.	H	SA-SI		+		+		
70	<i>Lobularia libyca</i> (Viv.) C.F. W. Meissn.	Ann.	Th	SA-SI		+				+
71	<i>Lolium perenne</i> L.	Per.	Th	ER-SR+ME+IR-TR	+	+				+
72	<i>Lolium temulentum</i> L.	Ann.	Th	ME+ER-SR+IR-TR		+				+

73	<i>Lotus creticus</i> L.	Per.	H	ME		+				+
74	<i>Lotus halophilus</i> Boiss.	Ann.	Th	ME+SA-SI		+				+
75	<i>Lycium schweinfurthii</i> Dammer in Engl.	Per.	Nph	ME		+				+
76	<i>Malva parviflora</i> L.	Ann.	Th	ME+IR-TR		+				
77	<i>Medicago intertexta</i> (L.) Mill. var. <i>Ciliaris</i> (L.) Heyn	Ann.	Th	ME+ER-SR		+				+
78	<i>Medicago polymorpha</i> L.	Ann.	Th	COSM						+
79	<i>Melilotus indicus</i> (L.) All.	Ann.	Th	ME+IR-TR+SA-SI		+				+
80	<i>Mesembryanthemum crystallinum</i> L.	Ann.	Th	ME+ER-SR	+	+				+
81	<i>Mesembryanthemum nodiflorum</i> L.	Ann.	Th	ME+SA-SI+ER-SR	+	+				+
82	<i>Moltkiopsis ciliata</i> (Forssk.) I.M. Johnst.	Per.	Ch	SA-SI+S-Z+ME		+				+
83	<i>Neurada procumbens</i> L.	Ann.	Th	SA-SI+S-Z		+				
84	<i>Nicotiana glauca</i> R.C. Graham	Per.	Ch	NAT		+				+
85	<i>Ononis serrata</i> Forssk.	Ann.	Th	ME+SA-SI		+				+
86	<i>Orobanche crenata</i> Forssk.	Ann.	P	ME+IR-TR	+	+				+
87	<i>Pancratium maritimum</i> L.	Per.	G	ME	+	+				+
88	<i>Parapholis incurva</i> (L.) C.E. Hubb	Ann.	Th	ME+IR-TR+ER-SR		+				
89	<i>Phalaris minor</i> Retz.	Ann.	Th	ME+IR-TR						+
90	<i>Phragmites australis</i> (Cuv.) Trin. ex Steud.	Per.	G,He	COSM	+	+		+	+	+
91	<i>Picris asplenoides</i> L.	Ann.	Th	ME+IR-TR		+				+
92	<i>Plantago squarrosa</i> Marray	Ann.	Th	ME		+				+
93	<i>Pluchea dioscoridis</i> (L.) DC.	Per.	Nph	S-Z+SA-SI						+
94	<i>Poa annua</i> L.	Ann.	Th	COSM	+	+				+
95	<i>Polygonum equisetiforme</i> Sibthi & Sm.	Per.	G	ME+IR-TR		+				
96	<i>Polypogon monspeliensis</i> (L.) Desf.	Ann.	Th	COSM		+				+
97	<i>Polypogo nviridis</i> (Gouan) Breistr.	Per.	H	ME+IR-TR		+				+
98	<i>Reichardia tingitana</i> (L.) Roth.	Ann.	Th	ME+SA-SI+IR-TR	+	+				+
99	<i>Rumex pictus</i> Forssk.	Ann.	Th	ME+SA-SI	+	+				+
100	<i>Salsola kali</i> L.	Ann.	Th	COSM	+	+				+

101	<i>Schoenoplectus litoralis</i> (Schrad.) Palla	Per.	G	PAL+ME					+	
102	<i>Schoenus nigricans</i> L.	Per.	G	ME+IR-TR+ER-SR		+				+
103	<i>Senecio glaucus</i> L.	Ann.	Th	ME+SA-SI+IR-TR	+	+	+			+
104	<i>Sesbania sericea</i> (Willd.) Link	Ann.	Th	PAL		+				+
105	<i>Sida alba</i> L.	Bi	Th	PAN				+		
106	<i>Silene succulenta</i> Forssk.	Per.	H	ME	+	+				
107	<i>Silene vivianii</i> steud.	Ann.	Th	SA-SI	+	+				+
108	<i>Sisymbrium irio</i> L.	Ann.	Th	ME+IR-TR+ER-SR						+
109	<i>Solanum nigrum</i> L.	Ann.	Th	COSM		+				+
110	<i>Sonchus oleracous</i> L.	Ann.	Th	COSM		+				+
111	<i>Spergularia marina</i> (L.) Griseb	Bi.	Th	ER-SR+ME+IR-TR		+		+		
112	<i>Sporobolus pungens</i> (Schreb.) Kunth.	Per.	G	PAN		+		+		
113	<i>Stipegrostis lanata</i> (Forssk.) De Winder	Per.	G	SA-SI		+	+			
114	<i>Suaeda maritima</i> (L.) Dumort. subsp. <i>salsola</i> (L.)	Ann.	Th	COSM				+		
115	<i>Suaeda apruinosa</i> Lang	Per.	Ch	ME				+		
116	<i>Suaeda vera</i> Forssk. ex J.F. Gmelin	Per.	Ch	ME+SA-SI+ER-SR				+		
117	<i>Symphyotrichum squamatum</i> (Spreng.) Nesom	Per.	Ch	NEO		+				+
118	<i>Tamarix nilotica</i> (Ehrenb.) Bge	Per.	Nph	SA-SI+S-Z		+		+		
119	<i>Tamarix tetragyna</i> Ehrenb.	Per.	Nph	SA-SI+ME+IR-TR	+	+				
120	<i>Urospermum picroides</i> (L.) F.W. Schmidt	Ann.	Th	ME+IR-TR		+				+
121	<i>Urtica urens</i> L.	Ann.	Th	ER-SR+ME+IR-TR						+
122	<i>Vigna luteola</i> (Jacq.) Benth	Per.	H	PAL		+				+
123	<i>Zygophyllum aegyptium</i> Hosny, Bot.	Per.	Ch	ME	+	+		+		
124	<i>Zygophyllum album</i> L.	Per.	Ch	SA-SI+ME		+		+		
125	<i>Zygophyllum coccineum</i> L.	Per.	Ch	SA-SI+S-Z		+		+		